Student Number: _____ (Print) Student Name: _____

Signature: _____

University of Saskatchewan
Dept. of Electrical Engineering

EE325 Communication Systems I

1 3
2 1
3 3
4 2
5 1½

10½/20

Midterm Examination - Friday, Feb. 16, 2000

Time: 2 hours

Textbook, Printed Notes and student's handwritten notes are permitted.

Where possible, use the space below each question for your answer.
Use the reverse side of the previous page for additional work.
Hand in your entire question paper; do not separate the pages.

Instructor: D.E. Dodds

1. Calculate the following to or

a) a 60 Hz tone at
What is the tota

$P_1 = P_o$

$A_1 = A_o = 12 P_1$
$= 0.4471$ V

400 mW X

b) an audio amplifier has voltage gain of 200. What is the voltage gain in dB? (one point)

Voltage gain (dB) $= 20 \log_{10}\left(\frac{V_o}{V_{in}}\right)$
$= 20 \log_{10}(200)$
$= 46.0$ dB ✓

c) a microwave amplifier has power gain of +13 dB. What is the ratio of output power to input power? (one point)

Power Gain (dB) $= 10 \log_{10}\left(\frac{P_o}{P_{in}}\right)$
$+13 = 10 \log_{10}\left(\frac{P_o}{P_{in}}\right)$
$20 = \frac{P_o}{P_{in}}$ ✓

d) A VCR outputs a -7 dBm, channel 3 signal on a 75 ohm cable and a second VCR outputs a -5 dBm, channel 4 signal. Both signals are linearly added without loss to form signal X on a 75 ohm cable. Determine the voltage level of signal X in volts rms. (one point)

$-7 dBm = 10 \log_{10}\left(\frac{P_o}{1 mW}\right)$
$P_{ch3} = 0.2$ mW

$-5 dBm = 10 \log_{10}\left(\frac{P_o}{1 mW}\right)$
$P_{ch4} = 0.32$ mW

$P_T = 0.52$ mW

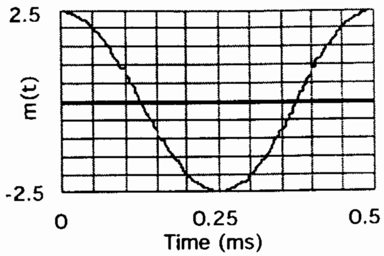
$P_T = \frac{(V_{rms})^2}{R}$

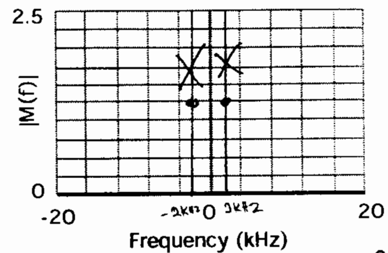
$0.52 mW = \frac{(V_{rms})^2}{75\Omega}$

$V_{RMS} = 0.1975$ V ✓

2. An analog multiplier is used to form the product $s(t) = m(t) \cdot c(t) / 1$ volt.
   (a) Sketch to scale and write an expression for the output signal, s(t). (2 points)
   (b) Sketch (to scale) the frequency spectrum of the three signals. (1 point)
   (c) Evaluate the normalized power in the product signal. (1 point)

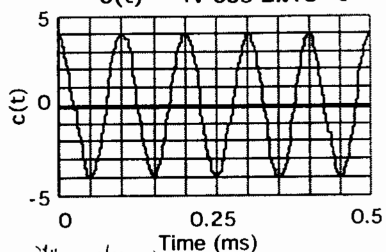
$m(t) = 2.5v \cos 2\pi 2000t$

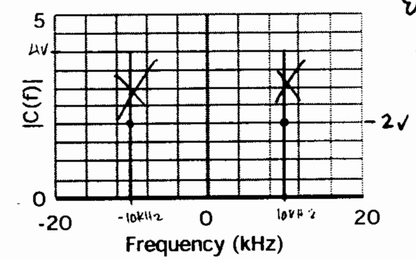


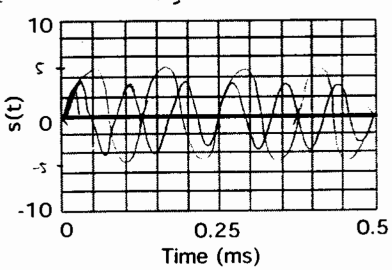


Review Euler's identity

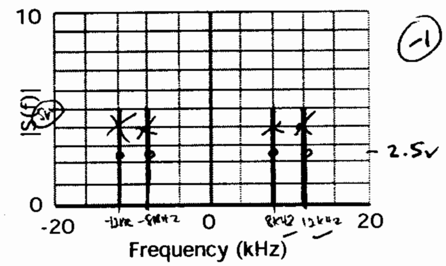
$c(t) = 4v \cos 2\pi 10^4 t$







(-1)



(-1)

s(t) = 5V[cos(2π 12kHz t) + cos(2π 8kHz t)]

P_s(normalized) = 12.5 W ✗

Ps normalized = $(V_{rms})^2$ = $(3.54V)^2$ = 12.5 W

5V = V_p

$V_{RMS} = \frac{5}{\sqrt{2}} = 3.54V$ (-1)

3(a) Which sampling format is used in commercial systems (i) flat top sampling or (ii) natural sampling? Explain why. (1 point)

Flat-Top Sampling ✓

This is because it uses narrower samples which can be extended at the receiver. This will allow many signals in a TDM multiplier ✓

The Flat-top has only one voltage value therefore only one value needs to be stored in PCM format

3(b) In a digital receiver, samples are placed in a latch (register) as they arrive and the content of the latch remains until the next sample arrives. The latch is connected to a D/A converter that is followed by an analog lowpass filter.
   (i) Does this system implement natural sampling or flat top sampling? (1 point)
   (ii) What is the duty cycle (in percent) of the decoded samples? (1 point)

i) Flat-top sampling ✓

ii) 100% ✓

3(c) The transmission gain of 33% natural sampling is 0.33 at all frequencies up to one half the sampling rate (fs/2). The transmission gain of 33% flat top sampling is 0.33 at zero Hz and is somewhat less as fs/2 is approached. Calculate the flat top sampling loss in dB (relative to natural sampling) at fs/4 and at fs/2. (1 point)

fs/4 : natural sampling gain is 0.33
Flat top sampling gain :

fs/2 : NS is : 0.33
FTS is :

(-1)

SNR = $A_{w..} =$ (

$f_s = 128$ kHz f_{BW}: 4 k
$f_m = 500$ Hz

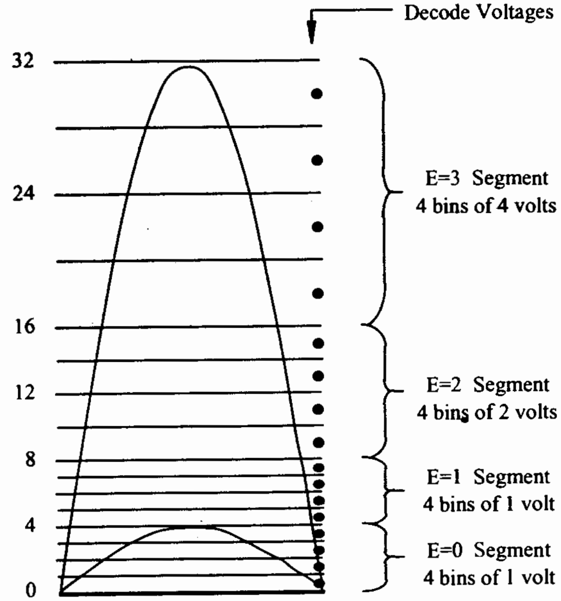
4(a) Complete the following drill problem (one point).

Drill Problem - SNR in DPCM - Assume a 500 Hz sinusoid, 128 kb/s transmission, 100 mV binsize for PCM, 50 mV stepsize for DM and DPCM and 4 kHz system bandwidth.

Signal	f_s (kHz)	P_s max (Watts)	P_{nf} (uW)	SNR_{max} (dB)
8 bit PCM	80	8.5		40.9 X
1 bit DPCM	128	"		40 X
2 bit DPCM	64	4.7	104.2	46.5
4 bit DPCM	32	"		69.5 X
Checksum	240	117.9	781.3	196.9

(−1)

4(b) A 5 bit non-uniform quantizer has 32 bins arranged in 4 groups, two with bin size one volt, one segment with bin size 2 volts and one with bin size 4 volts. An illustration of the positive half of the quantizing bins is shown along with the positive portions of a large and a small sinusoidal waveform. (note that this coding format is similar to "A Law") The 5 transmitted bits represent the quantizing bins with a sign, exponent and mantissa format. i) how many bits are allocated to mantissa? (one point) ii) calculate SNR for the large sinusoid and the small sinusoid. (two points)



i) 2 bits ✓

ii) large: use ~~32 bins~~ ~~5 bits~~   +16 / −16
SNR = 31.87 dB (−1)

Small: use 8 bins   +4 / −4
3 bits
SNR = 19.8 dB ✓

5(a) Complete the following short answer questions (2 points).

How many voice signals are carried by a DS1 signal? 24 voice signals ✓

How many voice signals are carried by a DS1-C signal? ≈ 48 ✓

How many framing bits are there in a DS1-C frame ? 12 ✓

What is the repetition period of frames in a DS1 system? 8 kHz OK

What is the repetition period of D3 superframes in a DS1 system? $\frac{1}{1.5\,ms}$ ✓ = 667 Hz

What is the repetition period of masterframes in a DS1-C system? 1546.3 Kb/s · 8 bits/byte · 1000b/Kb · [illegible] = 9725 Hz X

Do DS1 framing bits have constant timing (phase) relation with DS1-C framing bits? (YES) / NO X

(−1)

5(b) Complete the following short answer questions (2 points).

Why is bit stuffing required in the global digital transmission system ?

bit stuffing is needed to match both input rates up to 1546.3 kb/s. This permits synchronous multiplexing and demultiplexing. What is the basic problem? (−1/2)

What would be the disadvantage of reducing the number of framing bits to six per D3 superframe in a DS1 system ? Can you provide some numeric justification ?

Then you would only allow 6 frames per superframe, which would [illegible] (−1)

END